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Erodibility status of soils under different land uses in West Khasi hills of Meghalaya

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Summary

The effect of land use on soil erodibility parameters were studied in four villages, *viz.*, Nongstoin, Kynshi, Umyiap and Maweit in West Khasi Hills district, Meghalaya, under four land uses, *viz.*, lowland paddy, potato, forest and Jhum land, in each village. The textural class of the soils varied from silt loam to clay with dominance of clay loam texture. Dispersion ratio and erosion index were recorded to be usually higher than the threshold limits. A highly significant and negative relationship of erosion index with clay, silt + clay and highly significant and positive relationship with sand and dispersion ratio were observed. The increase in erosion index with increase in dispersion ratio indicated the susceptibility of these soils to water erosion. Proper soil and water conservation measures need to be adopted to protect the soils from further degradation.

Key words : Land uses, Dispersion ratio, Erosion index

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Introduction

Environmental degradation caused by unsuitable land use is a worldwide problem that has revitalized the issue of sustainability (Mandal *et al*., 2010). Soil erosion is a function of erosivity of rainfall and erodibility of soil. Soil erodibility refers to the soil inherent susceptibility to erosion by rainwater and runoff. This is a function of complex interaction of physical and chemical properties of soils affecting detachability, transportability and infiltration capacity. Soil erodibility depends primarily on the physical characteristics of soils, *viz.*, nature and amount of soil aggregates, organic matter content, particle size distribution, etc. The assessment of soil erodibility and its relationship with other parameters help in designing land management strategies to check the menace of soil erosion in hilly region. The assessment of erosion hazard can be quantified by different erosion indices of soil such as dispersion ratio and erosion index. The information pertaining to erodibility of soils of West Khasi Hills district of Meghalaya is very limited. Keeping this in view, the present investigation was undertaken to evaluate the erodibility behaviour of soils under different land uses in the region. Attempt was also made to find out the correlation among the erodibility indices as well as with mechanical composition of soil to identify the important soil properties which influence the erodibility of soils.

Resource and Research Methods

Soil samples from 0-15 and 15-30 cm depth were

collected from four different land uses, *viz.*, lowland-paddy, potato, forest and Jhum, from four different locations around Nongstoin, the headquarters of West Khasi Hills district *viz.*, Nongstoin, Kynshi, Umyiap and Maweit. Nongstoin is located between 25°31'N and 91°16'E longitude. It has an average elevation of 1409 metres above mean sea level. The climate of the study area is temperate to sub-tropical with mean annual temperature of 18ºC. The average annual rainfall ranges from 1200 mm to 3000 mm. These soil samples were processed and analysed for particle-size distribution following International Pipette method (Piper, 1966) using 0.5 N NaOH as a dispersing agent. The water holding capacity was determined using Keen Rackzowaski boxes as described by Baruah and Barthakur (1997). Suspension percentage (water dispersible silt + clay) was determined by dispersing 25g soil in 1000 ml distilled water without adding any dispersing agent, shaking end over end for 20 times and pipetting out 20 ml of soil suspension from 10 cm depth as suggested by Middleton (1930). The erodibility indices *i.e.* dispersion ratio and erosion index were computed using the procedures described by Middleton (1930) and Sahi *et al*. (1977), respectively as follows:

$$\text{Dispersion ratio} = \frac{\text{\% water dispersed (silt + clay)}}{\text{\% (silt - clay) particle – size analysis}}$$

$$\text{Erosion index} = \frac{\text{Dispersion ratio}}{\text{Clay / 0.5 water holding capacity}}$$

The statistical analysis of the data was done as per procedure outlined by Gomez and Gomez (1984).

Research Findings and Discussion

The findings of the present study as well as relevant discussion have been presented under following heads:

Mechanical composition of soil :

The sand content of surface and sub-surface soils in the different villages under various land uses varied from 6.35 to 36.10 per cent and 5.25 to 40.65 per cent, respectively (Table 1). The highest sand was recorded

Table 1: Textural class of soils under different land uses

Land use and location	Sand %		Silt %		Clay %		Textural class	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Paddy								
Nongstoin	13.20	16.45	37.05	53.20	48.75	29.35	Clay	Silty clay loam
Kynshi	6.35	5.25	42.60	34.40	50.05	59.35	Silty clay	Clay
Umyiap	30.05	22.90	48.40	43.05	20.55	33.05	Loam	Clay loam
Maweit	36.10	40.65	32.70	28.75	30.20	29.60	Clay loam	Clay loam
Mean	21.43	21.31	40.19	39.85	37.39	37.84	Clay loam	Clay loam
Potato								
Nongstoin	22.10	17.65	46.70	40.00	30.20	41.35	Clay loam	Silty clay
Kynshi	24.95	22.25	46.15	60.10	27.90	16.65	Clay loam	Silt loam
Umyiap	30.45	12.55	38.40	35.70	30.15	50.75	Clay loam	Clay
Maweit	20.80	18.65	43.25	39.50	34.95	40.85	Clay loam	Clay
Mean	24.58	17.78	43.63	43.83	30.80	37.40	Clay loam	Clay loam
Forest								
Nongstoin	18.60	14.50	31.95	43.50	48.45	41.00	Clay	Silty clay
Kynshi	32.00	38.50	30.90	36.80	36.10	23.70	Clay loam	Loam
Umyiap	25.65	24.70	49.10	40.20	24.25	34.10	Loam	Clay loam
Maweit	24.75	22.05	34.20	31.35	40.05	45.60	Clay	Clay
Mean	25.25	24.94	36.54	37.96	37.21	36.10	Clay loam	Clay loam
Jhum								
Nongstoin	33.05	30.95	51.15	33.20	14.80	34.85	Silt loam	Clay loam
Kynshi	25.30	34.60	53.50	33.50	20.20	30.90	Silt loam	Clay loam
Umyiap	22.55	21.25	42.55	47.60	33.90	30.15	Clay loam	Clay loam
Maweit	21.65	21.50	46.40	22.80	30.95	54.70	Clay loam	Clay
Mean	25.64	27.08	48.40	34.28	24.96	37.65	Loam	Clay loam
Average	24.22	22.78	42.19	38.98	32.59	37.25	Clay loam	Clay loam

in sub surface soil of Maweit village under paddy while the lowest was in sub surface soils of Kynshi village under paddy land use. The silt in the surface and sub-surface soils, irrespective of village and land use, ranged from 30.90 to 53.50 per cent and 22.80 to 60.10 per cent, respectively (Table 1). The maximum silt was found in sub surface soil of Kynshi village under potato land use while the lowest was recorded in sub surface soil of Maweit under Jhum land use. The clay in the surface and sub-surface soils in various villages under different land uses varied from 14.80 to 50.05 per cent and 16.65 to 59.35 per cent, respectively. The highest clay was recorded in surface soil of Kynshi under paddy land use while the lowest was in surface soil of Nongstoin under Jhum cultivation.

The textures of the soils in various land uses under different villages were recorded as silty clay, silt loam, silty clay loam, clay loam, loam and clay. The mean textural class of 0-15 cm soils under paddy, potato and forest land use was clay loam whereas, mean textural class under Jhum land use was loam. The mean textural class of 15-30 cm soil under all the land uses was recorded as clay loam. Goswami and Challa (2006) and Laxminarayana (2010) also reported similar results for the soils of Meghalaya. Singh and Dutta (1989) and Sharma *et al.* (2012) also reported similar findings for the soils of other North eastern states.

Dispersion ratio :

The dispersion ratio of the surface soils under paddy, potato, forest and Jhum land uses ranged from 16.78 to 50.87, 29.13 to 86.43, 12.93 to 76.42 and 39.76 to 59.99 with an average of 36.85, 51.81, 38.72 and 48.27, respectively (Table 2). The highest mean dispersion ratio in surface layer was found in Kynshi soils followed by Maweit, Umyiap and Nongstoin soils. The dispersion ratio of the sub surface soils under paddy, potato, forest and Jhum land uses varied from 7.75 to 43.85, 31.27 to 61.08, 26.51 to 66.12 and 14.11 to 52.17 with an average of 28.86, 45.36, 45.84 and 37.70, respectively. The maximum mean dispersion ratio in 15-30 cm soil layer was found in Maweit soils followed by Kynshi, Umyiap and Nongstoin soils. Considering upper limit of dispersion ratio as 15 suggested for non-erosive soil by Middleton (1930), all the soils are susceptible to erosion except surface soils of Maweit under forest and sub surface soils of Nongstoin under paddy and Jhum land uses. Aggregation, which may be due to clay and organic carbon content, leads to structural stability of soil resulting in low soil loss and soil erodibility values (Singh and Khera, 2006).

Dispersion ratio of <5, 6-10, 11-15, 16-25, 26-30 and >30 were categorized as very stable, stable, fairly stable, somewhat unstable, unstable and very unstable. Out of 32 soils, 24 were found to be very unstable, 2 unstable, 3 somewhat unstable, 2 fairly stable and 1 come under stable. Except the surface soil under forest in Maweit and sub surface soil under paddy in Kynshi, dispersion ratio in both surface and sub surface soils under all land uses in Umyiap, Kynshi and Maweit was recorded as very unstable. On the other hand dispersion ratio in surface soil of Jhum and sub surface soil of potato land uses in Nongstoin was observed as very unstable. Kahlon (2006) also found lower values of erosion ratio and dispersion ratio for the soil of forest and grasslands than those of arable and bare lands. In 10 out of 16 soil profile, dispersion ratio was higher in surface soils than in sub-surface soils which might be attributed to higher content of clay and soil aggregation in the lower depth.

Table 2 : Dispersion ratio of soils under different land uses

Village	Soil depth (cm)	Land use				
		Paddy	Potato	Forest	Jhum	Mean
Nongstoin	0-15	16.78	29.13	21.89	41.24	27.26
	15-30	7.75	41.30	26.51	14.11	22.42
Kynshi	0-15	37.99	86.43	76.42	52.10	63.23
	15-30	23.89	31.27	66.12	52.17	43.36
Umyiap	0-15	41.77	46.68	43.63	39.76	42.96
	15-30	39.95	61.08	38.76	37.04	44.21
Maweit	0-15	50.87	45.01	12.93	59.99	42.20
	15-30	43.87	47.79	51.98	47.48	47.78
Mean	0-15	36.85	51.81	38.72	48.27	
	15-30	28.86	45.36	45.84	37.70	

Similar observation was also reported by Mehta *et al.* (2005); Singh *et al.* (2006) and Sharma and Kumar (2010). Khera and Kahlon (2005) reported higher dispersion ratio and erosion index for bare soil as compared to forest soil.

Erosion index :

The erosion index of the surface soils under paddy, potato, forest and jhum land uses varied from 10.42 to 50.94, 30.99 to 73.87, 11.05 to 60.17 and 34.88 to 76.62 with an average of 33.09, 45.15, 32.53 and 62.92, respectively (Table 3). The maximum mean erosion index in surface layer was observed in Kynshi soils followed by Umyiap, Maweit and Nongstoin soils. The dispersion ratio of the sub surface soils under paddy, potato, forest and Jhum land uses ranged from 7.38 to 34.54, 28.43 to 39.17, 14.89 to 77.79 and 10.85 to 46.17 with an average of 21.19, 33.74, 39.02 and 29.66, respectively. The highest mean erosion index in 15-30 cm soil layer was recorded in Kynshi soils followed by Maweit, Umyiap and Nongstoin soils. Considering 2.8 as threshold value of erosion index (Sahi *et al.*, 1977), all the soils under study were qualified for erodible class and need conservation on priority to prevent them from getting further degradation. Comparatively higher erosion index in surface layers suggested that soils under all the land uses are more susceptible to sheet and rill erosion. Saha *et al.* (2011) from a soil erodibility characteristics study under modified land-use systems at Umiam, Meghalaya reported that Jhum cultivation showed the highest erosion ratio, followed by agriculture, indicating the need to adopt tree-based land-use systems for resource conservation.

Erosion index of 0-5, 6-10, 11-15, 16-20 and >20 were categorized as very low, low, medium, high and very high. Out of 32 soils, 25 were very high, 6 medium, 1 comes under low erosion index. The erosion index in all the soils under different land uses except the surface soil under forest in Maweit and sub surface soil under paddy in Kynshi was found as very high in Umyiap, Kynshi and Maweit villages. The erosion index in surface and sub surface soils of potato and surface soil of Jhum land use in Nongstoin was also recorded as very high. These results are in the line with the findings of Singh and Kundu (2008) and Sharma and Kumar (2010). Yilmaz *et al.* (2007) found that at cultivated and forested sites, the erosion index and dispersion ratio increased with increasing soil depth.

Relationship among dispersion ratio, erosion index and soil properties :

The correlation co-efficient values revealed that

Table 3: Erosion index of the soils under different land uses

Village	Soil depth (cm)	Land use				
		Paddy	Potato	Forest	Jhum	Mean
Nongstoin	0-15	10.42	30.99	11.46	76.37	32.31
	15-30	7.38	37.54	14.89	10.85	17.67
Kynshi	0-15	26.38	73.87	60.17	76.62	59.26
	15-30	12.57	28.43	77.79	46.17	41.24
Umyiap	0-15	50.94	32.87	47.42	34.88	41.53
	15-30	30.27	29.80	26.73	35.96	30.69
Maweit	0-15	44.62	42.87	11.05	63.82	40.59
	15-30	34.54	39.17	36.67	25.66	34.01
Mean	0-15	33.09	45.15	32.53	62.92	
	15-30	21.19	33.74	39.02	29.66	

Table 4 : Co-efficient of correlation between erodibility parameters and soil separates

Soil properties	Dispersion ratio	Erosion index
Dispersion ratio		
Erosion index	0.79**	
Sand	0.35*	0.51*
Silt + clay	-0.36*	-0.52*
Clay	-0.20	-0.60**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

sand and dispersion ratio had highly significant and positive correlation with erosion index (Table 4). The presence of higher amount of sand increased the erodibility of soil as it increased the dispersion ratio and erosion index. As the dispersion ratio increased, erosion index also increased indicating greater susceptibility of these soils to water erosion. The highly significant correlation between erosion index and dispersion ratio was also reported by Agnihotri *et al*.(2007). The significant negative correlation of dispersion ratio and erosion index with clay and silt + clay suggested that soil erodibility decreased with increase in clay and silt + clay content. Similar observations were also reported by Singh and Kundu (2008) and Sharma and Kumar (2010). It can be concluded that all the soil under study are susceptible to water erosion. Therefore, proper soil and water conservation measures need to be adopted to protect these soils from further degradation.

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